Offline Public Transportation Management System Based on GPS/WiFi and Open Street Maps

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Abstract—Recently, different technologies have been deployed to assist and manage transportation. Many concentrated efforts in academia and industry point to a paradigm shift in intelligent transportation systems. Vehicles will carry computing and communication platforms, along with enhanced sensing capabilities. Transportation faces many issues like high accidents rate in general, and much more rate in developing countries due to the lack of proper infrastructure for roads, is one of the reasons for these crashes. This work focuses on public transportation vehicles, where the goal of the project is to design and deploy a smart unit attached to public vehicles by using embedded microcontroller and sensors and empowering them to communicate with each other through wireless technologies such as WiFi. Our system mainly targeted to reduce traffic violations, by assuming that drivers are likely to change the way they drive if their vehicles are equipped with intelligent transportation equipment.

Keywords—ITS; GPS; WiFi; Transportation; OSM

I. INTRODUCTION

Intelligent Transportation Systems (ITS) have received much attention in recent years in academia, industry and standardization entities due to their wide impact on people’s life as their scope to provide vital applications and services to improve transportation safety, mobility, and optimizing the usage of available transportation resources. ITS applications and services rely on advanced technologies to be deployed and distributed among the intelligent infrastructure systems and vehicles system. Mainly, these technologies include, but not limited to physical world perceive technologies that able to perform real world measurements and convert them into the digital world, processing and storage capabilities that operate on the digital measurements by storing, analyzing them and communication technologies include wired and wireless technologies to exchange the collected data among the vehicles themselves and also to/from their infrastructure.

GPS tracking devices stand at the core of the enabling perceive technologies for ITS applications and services. Indeed, the number of vehicles’ GPS-enabled On-board Unit has sharply increased due to their vital and beneficial rules for both the vehicles and the drivers. GPS-based services include in-vehicle satellite navigation, vehicle security system, accident notification and tracking along with monitoring, and many other available services. Although most of GPS-based applications depend on real time information collection, the historic GPS collected data intrinsically has great potential for further offline based applications such as computing the journey speed, congestion monitoring, accidents deep analysis such as accident’s reason and driver’s behavior.

This project aims to build an open framework that focuses on traffic and vehicular data for enhancing Public Transportation Management System (PTMS) efficiency in terms of analysis and planning. The proposed framework consists of four main phases namely user data collection, transmission, data analysis and decision making.

The proposed solution uses a Smart onBoard Unit (SBU) that is attached to the public transportation vehicles, and a Web-based application running on a back-end centralized server. The SBU consists of an Arduino Uno microcontroller, GPS receiver, SD local storage, and WiFi communication module. More in details, the microcontroller hosts simple logic algorithm to control and manage other SBU’s components. While the GPS receiver, receives GPS signals for the available satellites and pass them to the microcontroller, by turn the microcontroller maintains the available data from GPS, the vehicle’s geographic location and speed. After that, the microcontroller decides either to store the newly generated data locally with SD storage or it will send the
local data through the WiFi Module to the back-end server, if the WiFi link is available. Finally, the web application manages a centralized database to store and retrieve all the data received from all the spread SBU s for further processing, analyzing, and visualizations.

The paper is organized as follows: the first section gives an Introduction about the problem and the proposed system. Related works are discussed in the second section. The model components are introduced in section three. System Model is depicted in section three, System requirements and implementation issues are described in section four. The Functional Testing and User Experience is proposed in the fifth section, while Conclusions are introduced in the final section.

II. RELATED WORK

This section briefly introduces implementation and development activities in research and academia of selected smart transportation systems. Specifically, GPS and GPRS based models which have been designed for managing and organizing transportation systems. Patinge and Kolhare developed a GPS based urban transportation management system in which the fleet tracking using GPS and GSM/GPRS technology and public information system unit mounted at bus [1]. Optimizing the traffic and passenger flows and improving system management, integrated real-time information on the traffic situation in the urban area (e.g., concerning parking spaces, congestion, and public transport) can be provided by CIVITAS II [2]. Goud and Padmaja proposed a useful approach in detecting accidents precisely by means of both vibration sensor and Micro electro Mechanical system (MEMS) or accelerometer [3]. Tarapiiah and others in [4], [5], [6] identify a common criteria and also they provide a design guideline for such system. Furthermore, they have developed in Palestine an initial prototype to control public transportation.

It is worth to mention that, most of the earlier studies, focus on real-time management systems, based on permanent link connections such as GSM/GPRS, and utilizing Google Maps, however, the proposed system focusing on a fee licensed technologies such as WiFi, in addition, we are using an open source OSM software.

III. SYSTEM MODEL

This section, describes the proposed framework, which consists of Three main phases, namely, user data collection, transmission, data analysis and decision making.

The first phase, data collection, uses off-the-shelf hardware components in order to build Smart on-Board Unit (SBU) that is fitted in to the public Transport Vehicles. SBU endowed with limited processing capabilities, temporary and persistent memory such as EPROM, GPS sensor and WiFi module to transfer the collected information to database storage. GPS tracking devices collect information regarding the vehicle such as the vehicles geographical location (i.e. longitude and latitude), speed and the driving direction at regular intervals of time.

In the second phase, transmission, since we are storing the data from the earlier phase onto SBU, here we are interested to transfer the information to a back-end server. The data is transferred via a WiFi link to the to the access point located in the main bus station which act as a gateway connected through the internet to the back-end server.

The last phase, data analyses, the core of this phase is to inject the bus geographical location at a given timestamp along the trip on a digitized map such as open street maps (OSM), each street segment has different attributes such as the street category (pedestrian, highway or motorway) each category has a maximum allowed speed attribute. Here, we record the number of times a vehicle violates these speed limits and the corresponding violation time durations. The resulted information is compared to predefined threshold and limits which allows the system to decide whether the vehicle violated the traffic regulations or not at a given trip.

After running our model for long enough periods, we expect that tracking and ticketing system can be fed by authorized department which can be utilized to get clear view about infrastructure which can be used for developing and planning to improve the infrastructure on some field or apply some regulations which will aim to reduce traffic accidents.

IV. ARCHITECTURE AND IMPLEMENTATIONS

This section depicts the high level architecture (as shown in Figure 1) of the proposed system by identifying the main building blocks of the SBU. In addition, the Web based application running on the back-end server is introduced.

A. Smart on-Board Unit (SBU) Main Component

Here we provide detailed description about the used hardware modules by the SBU:
1) The Arduino Uno (DEV-11021) which is an open hardware source controller, which is recently being used in many applications, due to its high performance, and easy to deal with. the Arduino Microcontroller board is based on the ATmega328, which has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, 32k Flash Memory, a USB connection, a power jack, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC to DC adapter or battery to get started [7].

2) Arduino GPS Shield (GPS-10710) Figure 3 is a high accuracy GPS receiver, which is used in our system due to its great characteristics and features, such as, this module can be easily integrated to the Arduino board, GPS-10710 is able to give the vehicle location within a few meters, this GPS module also gives accurate time readings, which is an important feature to provide a good distributed synchronization mechanism to our system and all the control messages between the GPS receiver, and the Arduino microcontroller, are performed using the well-known AT commands standard [7].

3) Arduino Wi-Fi Shield (DEV-11287) Figure 4: this Shield allows an Arduino board to connect to the internet using the 802.11b/g wireless specification. The shield has an Atmega 32UC3 which provides a network (IP) stack capable of both TCP and UDP. In addition, the shield has an on-board micro-SD card slot, which is mainly used to locally store the user data on SBU along the trip, before being transferred to the central server via WiFi link. [7].

B. Web Based Application

In order to make our Web Application flexible and extensible, we have adapted the REST (RESTful) architecture. And our implemented system has used the three-tier architecture [8]

1) A front-end which relate to the client side. The user interface is based on a web-browsers application. It contains a responsive web-page developed using Hypertext Transfer Markup Language v.5 HTML5, Javascript, JQuery library and Cascading Style Sheet (CSS) whose application is tested on both desktop and smart-phone web browsers. This web-page uses Asynchronous JavaScript AJAX in order to build bidirectional data flow with middle layer.

2) A middle layer which includes a dynamic PHP program running on top of Apache web server. This program exposes its internal functionality through a RESTful interface towards the front-end and it uses the MySQL native driver for PHP for storing and retrieving data.

3) A back-end containing MySQL database server used to store all known roads in the region, system users, users profiles and user alerts. This component is a relational database that is used to store and retrieve the data. Note that the positioning and speed data are time-stamped according to the UTC time reference.

In RESTful vocabulary things are resources. Each resource is a uniquely addressable entity by a Universal Unique Identifier (URI) attached to it. Moreover, each resource has a representation which can be transferred and
V. Functional Testing and User Experience

In order to test the system prototype, we attached our system box to a public transportation vehicle (mini-bus) traveling on the same route/path between two cities; namely, from Tulkarem to Nablus.

We have collected and locally recorded the trips information (i.e. long., lat., Speed, and timestamp), based on the system model, these information is transferred via WiFi link to the gateway allocated in the final bus station, by turn, such data is inserted in the corresponding Database. Then it was analyzed to get the driver's behavior, we are interested in two kind of plots, first plot Figure 5 depicts for each trip, the vehicle speed along the route, while in the second plot as in Figure 6 we show the traveled path along the trip, notice that, the corresponding plot was generated using Open Street Maps (OSM) API [9]. We have considered for analysis ten different trips of the same driver with the same vehicle, it is worth to mention that, these data are collected almost in the same time during a normal working day with almost same weather conditions. In order to analyze the speed violation, we know that the maximum allowed speed limit on the outside city roads in Palestine is configured to be 90 Km/h, by looking to Figure 5, we notice that, the driver in the first trip does not exceed the maximum allowed speed limit; the connected blue horizontal line, indicates the 90Km/h speed limit. moreover, we could notice that the driver in the trip 102 (b) violates the speed limit frequently in comparison to other trip.

Furthermore, Figure 6 shows the followed path for the first four trips, we found that all trips follow the same path along the route, in addition, we indicates on the track (red points) the segments where the driver violates the maximum speed limit, in fact, by referring to the authorized national transportation system, we found that recently, many traffic accidents happened on that segment.

VI. Conclusions

This paper introduces system composition structure for the proposed Offline Intelligent Public Transportation Management System which play a major role in reducing risks and high accidents rate, whereas it can increase the traveler satisfactions and convenience. Here, we propose a method, software as well as a framework as enabling technologies for evaluation, planning and future improvement the public transportation system. Our system even though can be as whole or parts can be applied all over the world we mostly target developing countries. This limitation mostly appears by consider off-shelf technologies such as Wi-Fi, GPS and OSM. In our system, the Open Street Maps plays a major role during monitoring, visualization and identifying the maximum allowed speed for each road segment along with the traveled route.

REFERENCES